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# Python - Spatial Analysis (Intermediate)

Jason Pardy & Nobbir Ahmed

# Today's Agenda

- Builds on ***Python – Getting Started***
- **Walkthrough – Create a analytical tool to do Quadrat Analysis**

1. Python 201: data structures & functions
2. Script tools
3. Creating and using classes for parameter values
4. Accessing data with cursors
5. Making scripts more efficient

- More on cursors and working with geometries

# ArcPy

- The access point to geoprocessing tools
- A package of functions, classes and modules, all related to scripting in ArcGIS
  - Functions that enhance geoprocessing workflows (ListFeatureClasses, Describe, SearchCursor, etc)
  - Classes that can be used to create complex objects (SpatialReference, FieldMap objects)
  - Modules that provide additional functionality (Mapping, SpatialAnalyst modules)
- Extends on arcgisscripting module (pre-10.0)

# Python 201

# Take advantage of key Python data structures

| Type | Explanation | Example |
|---|---|---|
| List | Flexible ordered collection | L = ["10 feet", "20 feet", "50 feet"] |
| Tuple | An immutable list (not editable) | T = ("Thurston", "Pierce", "King") |
| Dictionary | Key/value pairs | D = {"ProductName": "desktop", "InstallDir": “c:\\ArcGIS\\Desktop10.0"} |

# List comprehensions

- **Provides a clean and compact way of mapping a list into another list by applying a function to each of the elements of the list**

**List Comprehension**

```
>>> states = [' california', ' alaska', ' maine ']
>>> states2 = [state.strip() for state in states]
>>> print states2
[‘california', ‘alaska', ‘maine']
```

# Defining Functions

- **A simple way to organize and re-use functionality**

```
import arcpy

def increase_extent(extent, factor):
    """Increases the extent by the given factor"""

    XMin = extent.XMin - (factor * extent.XMin)
    YMin = extent.YMin - (factor * extent.YMin)
    XMax = extent.XMax + (factor * extent.XMax)
    YMax = extent.YMax + (factor * extent.YMax)

    return arcpy.Extent(XMin, YMin, XMax, YMax)

oldExtent = arcpy.Describe("boundary").extent
newExtent = increase_extent(oldExtent, .1)
```

Define your function

Return a result

Call the function

# Python 2.6

- ArcGIS 10.0 supports and installs Python 2.6
- The development of Python 3.0 has influenced many features in 2.6.
  - The % operator is supplemented by a more powerful string formatting method, .format()
  - The print statement becomes the print function in 3.0.
    - Python 2.6 has a __future__ import, letting you use the functional form instead. For example:

```
>>> from __future__ import print_function
>>> print('Hello world')
```

- http://docs.python.org/whatsnew/2.6.html

# Demo – Python 201

Python Data Structures

```
Python
>>> def get_value(key):
...     ii = arcpy.GetInstallInfo()
...     return ii.get(key)
...
>>> get_value('InstallDir')
u'c:\\program files (x86)\\arcgis\\desktop10.1\\'
>>>
```

# Quadrat Analysis Walkthrough

# Demo – the Quadrat Analysis tool – Step 1

# Python & the Georpocessing Framework

- Tightly integrated
  - No UI programming
  - Script tools look & behave like core GP tools
  - Script tools provide default validation
  - Documentation of script tools is the same as core tools

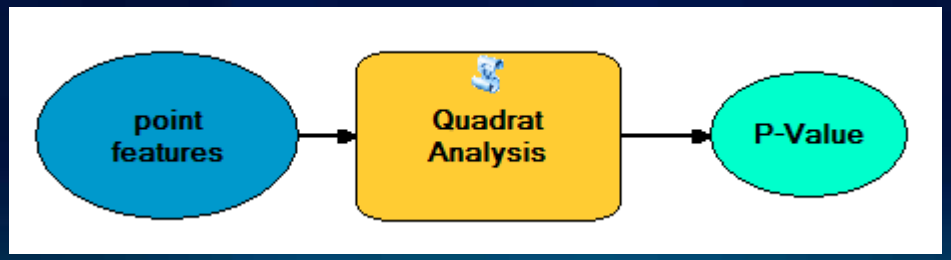
# Creating a script tool…

- Script tool must include input and output arguments
  - Use GetParameterAsText() or GetParameter() to obtain script argument values

- Script must include messaging
  - Return informative messages during execution of the script
  - Return error messages when a problem arises
  - Three functions to support tool messaging
    - AddMessage()
    - AddWarning()
    - AddError()

# Script tools – Output parameters

- All tools should have an output
  - If the script updates an input dataset, create a derived parameter
  - If an output parameter is a scalar value, make it derived
    - Use SetParameterAsText() or SetParameter() functions to set it at the end of your script
    - Allows chaining of the output value in a model



# Jump Start Your Python Project with a Script Template

```
#-------------------------------
# Name:        template.py
# Purpose:
# Author:
# Created:     23/06/2011
# Copyright:   (c) company name
# ArcGIS Version:   10
# Python Version:   2.6
#-------------------------------
import os
import sys
import arcpy

def main(*argv):
    """TODO: Add documentation about this function here"""
    try
        #TODO: Add analysis here
        pass
    except arcpy.ExecuteError:
        print arcpy.GetMessages(2)
    except Exception as ee:
        print ee.args[0]
# End main function

# Ensures this file is usable as a script, script tool, or as an
importable module
if __name__ == '__main__'
argv = tuple(arcpy.GetParameterAsText(i)
             for i in range(arcpy.GetArgumentCount()))
    main(*argv)
```

# Quadrat Analysis script- Step 2

Jump start our analysis using a template

# ArcPy Classes

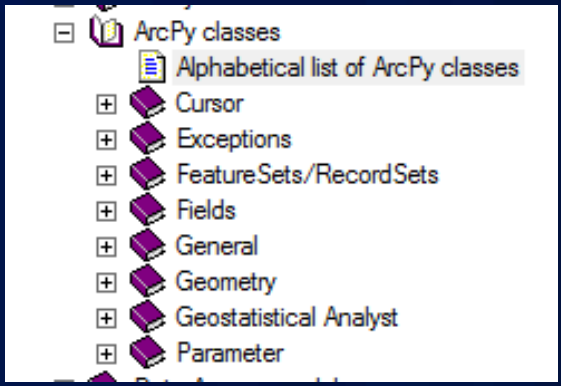
# Classes

- Classes can be used to create objects
- Some  parameters cannot be easily defined with a string
  - Such as a spatial reference or extent
- Classes can be used to define parameters

```
installdir = arcpy.GetInstallInfo()['InstallDir']

prj_file = os.path.join(installdir, “North America Equidistant Conic.prj”)

# Create a spatial reference using a projection file
spatial_ref = arcpy.SpatialReference(prj_file)

# Run CreateFeatureclass using the spatial reference
arcpy.CreateFeatureclass_management(input_workspace,
    output_name, "POLYLINE", "", "", "", spatial_ref)
```

# Classes cont…

- A better user experience




```
point = arcpy.Point(25282, 43770)
point_geom = arcpy.PointGeometry(point)
arcpy.Buffer_analysis(point_geom, “in_memory/point_buffer”, “250 Meters”)

extent = arcpy.Describe(feature_class).extent
arcpy.CreateRandomPoints_management("c:/data", "samplepoints", “", extent, 500)
```

# Accessing Data with Cursors

# Cursors

| Type | Explanation |
|---|---|
| SearchCursor (dataset, {where_clause}, {spatial_reference}, {fields}, {sort_fields}) | Read-only access to field values, geometry |
| UpdateCursor (dataset, {where_clause}, {spatial_reference}, {fields}, {sort_fields}) | Update or delete field values, replace geometries |
| InsertCursor (dataset, {spatial_reference}) | Add new records to a table or feature class; write field values and geometry |

# Cursors

- ArcPy cursors support iteration

```
for row in arcpy.SearchCursor(table):
    print (row.getValue("FieldName"))
```

# Cursors

- Cursors have optional arguments
  - Need coordinate information in a different coordinate system?
  - Features may be projected on-the-fly using the Spatial Reference parameter

```
# Create a SR object from a projection file
SR = arcpy.SpatialReference("c:/NAD 1983 UTM Zone 10N.prj”)

# Create search cursor, using spatial reference
rows = arcpy.SearchCursor("D:/data.mdb/roads","", SR)
```

# Quadrat Analysis – Step 2

- Extent class
- Search Cursor
- GP Tools
- Chi-square function

## Performance Tips:

- Use *in_memory* workspace for intermediate datasets

  in_memory\outputFC

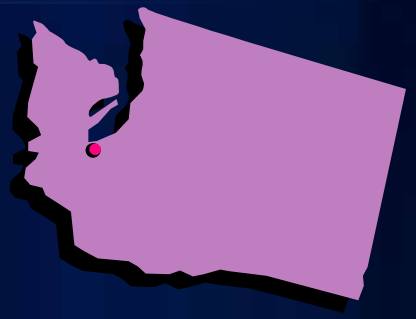
- Provide a set of fields to cursor functions

```
srows = arcpy.SearchCursor(input_fc, “”, “”, “fieldA;fieldB”)
```

# Quadrat Analysis – Recap

- Development time was fast:
  - A script template jump started our development
  - ArcPy provided quick and easy access to tools and functions
  - Script tool meant no UI development
  - Script tools provided default validation
- Took advantage of a function to define and group a useful piece of functionality
- Took advantage of open source libraries (i.e. numpy)
- Easy to share and deploy
  - No ArcObjects or dlls to register

# Reading Geometry



- Feature classes have a geometry field
  - Typically *(but not always)named Shape*
- Returns a geometry object
  - Has properties that describe the feature
  - area, length, isMultipart, partCount, pointCount, type, ...
- Geometry objects can often be used in place of feature classes

```
# Buffer each feature to a new feature class

for row in arcpy.SearchCursor("C:/data/Roads.shp"):
  geom = row.getValue("Shape")
  name = row.getValue("Name")

  print (geom.length)
  arcpy.Buffer_analysis(geom, "buffer_{0}".format(name), "100 Feet")
```

# Reading Feature Geometry

- You must understand the hierarchy for geometry in order to use it
  - A feature class is made of features
  - A feature is made of parts
  - A part is made of points
- In Python terms
  - A single part feature looks like this

    [pnt, pnt, pnt]
  - A multipart polygon feature looks like this

    [[pnt, pnt, pnt],[pnt, pnt, pnt]]
  - A single part polygon feature with a hole (inner ring) looks like

    [[pnt, pnt, pnt, None ,pnt, pnt, pnt]]

# Reading Feature Geometry

```
for row in arcpy.SearchCursor(polygonFC):

    for part in row.shape:
        pnt = part.next()

        while pnt:
            print pnt.X, pnt.Y
            pnt = part.next()

            if not pnt:
                pnt = part.next()
                if pnt:
                    interiorRing = True
```

Loop through each row

Loop through each part in a feature

Loop through each point in a part

For polygons, watch for interior rings

# Writing Feature Geometry

- Insert cursors must be used to create new features

```
icur = arcpy.InsertCursor("D:/data.gdb/roads")
row = icur.newRow()
```

- Use Point and Array classes to create feature parts
- A part may be used to set a geometry field
  - A multipart feature is an array containing other arrays, where each array is a part

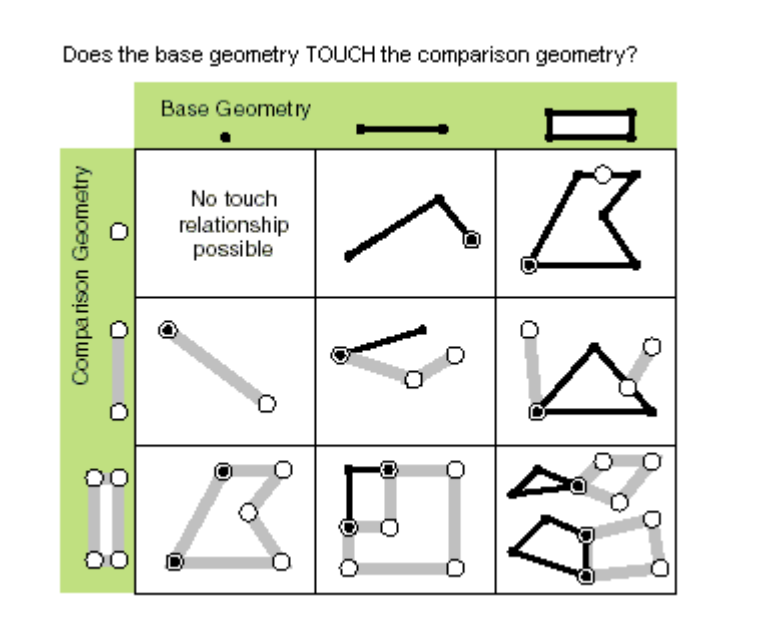
- An Update cursor can be used to replace a row's existing geometry

# Writing Feature Geometry

```
# Open an insert cursor for the feature class
icur = arcpy.InsertCursor(fc)

# Create array and point objects
pt_list = [arcpy.Point(358331, 5273193),
           arcpy.Point(358337, 5272830)]

line_array = arcpy.Array(pt_list)

# Create a new row for the feature class
feat = icur.newRow()

# Set the geometry of the new feature to the array of points
feat.Shape = line_array

# Insert the feature
icur.insertRow(feat)

# Delete cursor
del icur
```

# Geometry operators

- Python geometry objects support relational operators at 10
  - contains
  - crosses
  - disjoint
  - equals
  - overlaps
  - touches
  - within



# Geometry operators

```
import arcpy
line1 = arcpy.Polyline(arcpy.Array([arcpy.Point(1,10), arcpy.Point(10,10)]))
line2 = arcpy.Polyline(arcpy.Array([arcpy.Point(5,5), arcpy.Point(7,15)]))

# Does line1 cross line2? crosses return a boolean
line1.crosses(line2)
```

# Demo - Geometry operators

Finding overlaps

# Learning Python with ArcGIS

- **Resource Center**
  - http://resources.arcgis.com/geoprocessing/
- **Desktop Help**
- **Python Tips, Tricks, and Hacks**
- **Have a good Python Reference**
  - **"Learning Python" by Mark Lutz**
    - **published by O'Reilly & Associates**
  - **"Core Python" by Wesley J. Chun**
    - **published by Prentice-Hall**
  - **Python Standard Library by Example –**
    - **Doug Hellman**

# Review of IDEs for Python

- Which Python IDE is best?

# Esri Training for Python

*http://www.esri.com/training*

- **Instructor-Led Course**
  - Introduction to Geoprocessing Scripts Using Python
- **Web Course**
  - Using Python in ArcGIS Desktop 10

# Additional Python Technical Sessions

- Python – Raster Analysis
- - Wed 3:15pm Room 5 A/B

- Using R in ArcGIS
- - Wed 12:00pm Room 1 A/B

- Python - Scripting for Map Automation
  - Wed 3:15pm Room 9

- Building Tool with Python
- - Thu 10:15am Room 9

***Questions?***

***Survey: www.esri.com/sessionvals***